Saturn Scatterometry Rev 276

R. West

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- Sequence: s100
- Rev: 276
- Observation Id: ri_276_1
- Target Body: Saturn

1 Introduction

This memo describes one of the Cassini RADAR activities for the s100 sequence of the Saturn Tour. A sequence design memo provides the science context of the scheduled observations, an overview of the pointing design, and guidelines for preparing the RADAR IEB. A 3-hour warmup occurs first using the parameters shown in table 3.

2 CIMS and Division Summary

CIMS ID	Start	End	Duration	Comments
276RI_WARMUP001_RIDER	2017-148T09:35:00	2017-148T12:17:00	02:42:0.0	
276RI_INBHIRES001_PIE	2017-148T12:17:00	2017-148T14:19:00	02:02:0.0	

Table 1: ri_276_1 CIMS Request Sequence

Each RADAR observation is represented to the project by a set of requests in the Cassini Information Management System (CIMS). The CIMS database contains requests for pointing control, time, and data volume. The CIMS requests show a high-level view of the sequence design.

The CIMS requests form the basis of a pointing design built using the project pointing design tool (PDT). The details of the pointing design are shown by the PDT plots on the corresponding tour sequence web page. (See https://cassini.jpl.nasa.gov/radar.) The RADAR pointing sequence is ultimately combined with pointing sequences from other instruments to make a large merged c-kernel. C-kernels are files containing spacecraft attitude data.

A RADAR tool called RADAR Mapping and Sequencing Software (RMSS) reads the merged c-kernel along with other navigation data files, and uses these data to produce a set of instructions for the RADAR observation. The RADAR instructions are called an Instrument Execution Block (IEB). The IEB is produced by running RMSS with a radar config file that controls the process of generating IEB instructions for different segments of time. These segments of time are called divisions with a particular behavior defined by a set of division keywords in the config file. Table 2 shows a summary of the divisions used in this observation. Subsequent sections will show and discuss the keyword selections made for each division. Each division table shows a set of nominal parameters that are determined by the operating mode (eg., distant scatterometry, SAR low-res inbound). The actual division parameters from the config file are also shown, and any meaningful mismatches are flagged.

Division	Name	Start	Duration	Data Vol	Comments
a	distant_warmup	-5:00:0.0	02:56:0.0	2.6	Warmup
b	distant_radiometer	-2:04:0.0	00:03:30.0	0.2	Radiometer quick-steps
c	scat_rings	-2:00:30.0	00:12:30.0	105.0	scatt on A-ring
d	scat_rings	-1:48:0.0	00:12:0.0	111.6	scatt on A-ring
e	scat_rings	-1:36:0.0	00:12:0.0	118.8	scatt on A-ring
f	scat_rings	-1:24:0.0	00:04:0.0	42.0	scatt on A-ring
g	sar_lo_rings	-1:20:0.0	00:09:0.0	99.9	sarl on B-ring
h	sar_lo_rings	-1:11:0.0	00:05:36.0	65.5	sarl on B-ring
i	sar_lo_rings	-1:05:24.0	00:04:24.0	52.8	sarl on B-ring
j	sar_lo_rings	-1:01:0.0	00:16:0.0	192.0	sarl on B-ring
k	scat_rings	-0:45:0.0	00:05:0.0	60.0	scatt on C-ring
l	scat_rings	-0:40:0.0	00:10:0.0	114.0	scatt on C-ring
m	scat_rings	-0:30:0.0	00:05:0.0	33.0	scatt on C-ring
n	scat_rings	-0:25:0.0	00:03:0.0	19.8	scatt on C-ring
o	scat_rings	-0:22:0.0	00:02:0.0	12.0	scatt on C-ring
p	sar_lo_rings	-0:20:0.0	00:07:0.0	84.8	sarl on C-ring
q	sar_hi_rings	-0:13:0.0	00:04:0.0	48.0	sarh on C-ring
r	alt_rings	-0:09:0.0	00:07:54.0	52.1	altimeter when close, no target expected
s	distant_radiometer	-0:01:6.0	00:02:12.0	0.1	Radimeter division replaced by custom dust probe
t	distant_radiometer	00:01:6.0	00:02:54.0	0.2	Closing Radiometer
Total				1214.5	

Table 2: Division summary. Data volumes (Mbits) are estimated from maximum data rate and division duration.

Name	Nominal	Actual	Mismatch	Comments
mode	radiometer	radiometer	no	
start_time (min)	varies	-300.0	no	
end_time (min)	varies	-124.0	no	
time_step (s)	varies	3600.0	no	Used by radiometer only modes - saves commands
bem	00100	00100	no	
baq	don't care	5	no	
csr	6	6	no	6 - Radiometer Only Mode
noise_bit_setting	don't care	4.0	no	
dutycycle	don't care	0.38	no	
prf (Hz)	don't care	1000	no	
tro	don't care	0	no	
number_of_pulses	don't care	8	no	
n_bursts_in_flight	don't care	1	no	
percent_of_BW	don't care	100.0	no	
auto_rad	on	on	no	
rip (ms)	34.0	34.0	no	
max_data_rate	0.248	0.248	no	Kbps - set for slowest burst period
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 3: ri_276_1 Div a distant_warmup block

3 Overview

This observation is the second of the active ring scans. It occurs in a proximal orbit where the spacecraft passes through the ring plane just inside of the rings. The pointing design sweeps the central beam across the rings starting from the outer A-ring when the spacecraft is farthest out. (See fig. 1) The spacecraft is inbound to the ring plane when the turn to the IVD pointing profile completes and range to the beam footprint varies from around 150000 km to 0 km. The beam footprint size which sets the real aperture resolution varies from 1000 km down to around 100 km while looking at the rings. The beam footprint is moved slowly over the course of about two hours to allow many looks to accumulate. The pointing design keeps the beam aimed at a point along the line joining the sub-spacecraft point in the ring plane with the center of Saturn. This ensures that iso-range contours in the ring plane will be nearly parallel to iso-radius contours. Range compression processing can then be used to improve radius resolution from the real aperture limit. How much improvement will depend on signal strength, and ambiguity limitations. The radar mode (ie., bandwidth) is varied during this scan to allow for the best possible range resolution. The signal strength was estimated assuming a normalized backscatter of 1.0. The high spacecraft velocity leads to very high doppler shifts, so doppler ambiguities are unavoidable and doppler processing is not expected to be useful. The minimum PRF is also limited by the instrument command parameters, and range ambiguities will be present in much of the data. Since many looks are accumulated, and the rings are effectively a 1-D target, a deconvolution algorithm should be able to unravel the range ambiguities. Limitations on the number of instructions will also introduce some time domain clipping. The high range to the ring plane requires multiple bursts in flight for the more distant parts of the scan which placed further limitations on the PRF used.

4 Trigger Time Error

This observation and the subsequent RI 277 observation were affected by a 100 second trigger time error. Due to this error, the range and frequency gates were mis-aligned which causes both time and frequency domain clipping. The range gate refers to the time during which echo energy is expected to arrive back at the spacecraft. The frequency gate refers to the range of Ku-band frequencies over which the chirp echo will occur including the effect of doppler shift. Normally, the IEB generating software computes values for the receive window delay and the chirp start frequency based on the expected delay and frequency of echoes from the center of beam 3. A trigger time error means these values were computed for a time-shifted point in the trajectory. The impact of this error depends on how range and doppler vary during the observation. The impact is most severe on the scatterometer mode divisions which have less frequency margin. In the later part of this observation, the echoes from the C-ring are completely missed by the scatterometer mode divisions, but partially captured by the sar-lo mode divisions. Any processing algorithm will need to account for the time and frequency domain clipping in these two observations.

5 Dust Detection Experiment

This observation contains a dust detection experiment during the ring plane crossing which occurred at the end of the observation time. During the ring plane crossing, the spacecraft pointed its high gain antenna into the direction of orbital motion to protect the instruments and spacecraft systems from damage due to impacting dust particles. Although these dust particles were not expected to damage the high gain antenna, they could generate electrical signals that are detectable by the radar receiver. Therefore, the radar kept operating across the ring plane crossing to see if such dust impact events were observable. Both active and passive modes were used here. In the configuration file, divsion S covers the nominal ring plane crossing time. The division parameters are for radiometer only mode, however, this time interval was manually replaced by an altimeter mode collection to provide a high sample rate data set suitable for locating short strong events. The trigger time error shifted this special block away from the ring plane crossing time. Fortunately, the preceeding altimeter division had parameters similar to those put in division S, so useful data should still have been collected during the ring plane crossing. The radiometer mode data provides longer time integrations and wider bandwidths that are more likely to capture dust impacts, but raw samples are not available so the dust impacts may not be visible. Similar dust detection experiments were repeated in the ri 277 and ri 282 observations.

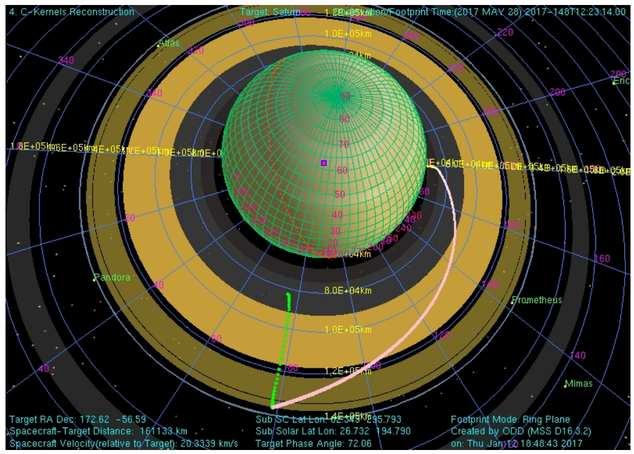

Figure 1: PDT view of RI 276 observation.

Name	Nominal	Actual	Mismatch	Comments
mode	scatterometer	scatterometer	no	
start_time (min)	varies	-96.0	no	
end_time (min)	varies	-84.0	no	
time_step (s)	don't care	12.0	no	manually set
bem	00100	00100	no	
baq	varies	7	no	7 - 8-4
csr	8	0	yes	0 - fixed attenuation
noise_bit_setting	varies	4.0	no	
dutycycle	0.70	0.45	yes	0.45 to stay below limits
prf (Hz)	don't care	1300	no	
tro	don't care	6	no	
number_of_pulses	don't care	70	no	
n_bursts_in_flight	1	3	yes	accomodating long range operation
percent_of_BW	100	100.0	yes	
auto_rad	on	on	no	
rip (ms)	34.0	34.0	no	
max_data_rate	varies	165.000	no	
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 4: ri_276_1 Div e scat_rings block

6 Revision History

1. Apr 6, 2017: Initial Release

7 Acronym List

ALT	Altimeter - one of the radar operating modes
BAQ	Block Adaptive Quantizer
CIMS	Cassini Information Management System - a database of observations
Ckernel	NAIF kernel file containing attitude data
DLAP	Desired Look Angle Profile - spacecraft pointing profile designed for optimal SAR performance
ESS	Energy Storage System - capacitor bank used by RADAR to store transmit energy
IEB	Instrument Execution Block - instructions for the instrument
ISS	Imaging Science Subsystem
IVD	Inertial Vector Description - attitude vector data
IVP	Inertial Vector Propagator - spacecraft software, part of attitude control system
INMS	Inertial Neutral Mass Spectrometer - one of the instruments
NAIF	Navigation and Ancillary Information Facility
ORS	Optical Remote Sensing instruments
PDT	Pointing Design Tool
PRI	Pulse Repetition Interval
PRF	Pulse Repetition Frequency
RMSS	Radar Mapping Sequencing Software - produces radar IEB's
SAR	Synthetic Aperture Radar - radar imaging mode
SNR	Signal to Noise Ratio
SOP	Science Operations Plan - detailed sequence design
SOPUD	Science Operations Plan Update - phase of sequencing when SOP is updated prior to actual sequencing
SSG	SubSequence Generation - spacecraft/instrument commands are produced
SPICE	Spacecraft, Instrument, C-kernel handling software - supplied by NAIF to use NAIF kernel files.
TRO	Transmit Receive Offset - round trip delay time in units of PRI